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Effect of Plant Extracts and Packaging Materials on Prolonging Shelf Life and Maintaining Quality of Mandarin (*Citrus reticulate* Blanco.)

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Abstract— *An experiment was conducted in Complete Randomized Design (CRD) with four replications and seven treatments, from Jan-Mar 2019 at ambient room condition (14.42±1.28°C, 58.46±3.46% RH) to evaluate the effect of different postharvest treatments on maintaining shelf life and quality of mandarin. The seven treatment used during experiment were Control, Titepati leaf extract (10% w/v), Marigold flower extract (10% w/v), Asuro leaf extract (10% w/v), Neem leaf extract (10% w/v), Newspaper wrapping and Perforated plastic. The parameters like juice recovery percentage, total soluble solid (TSS) and pH were taken from destructive sample at every 5 days interval and other parameters like physiological weight loss, pathological disorder, marketability and shelf life were observed from non-destructive at every 4 days interval. Post-harvest treatment with perforated plastic had minimum physiological loss in weight (16.32%) whereas control had highest physiological loss in weight (35.47 %) which is statistically at par with Newspaper wrapping (33.28%). Highest juice recovery percentage was recorded in perforated plastic (36.12%) whereas lowest juice recovery percentage was recorded in treatment control (26.70%) which was statistically at par with Newspaper wrapping (27.24%). At the end of storage period, the highest TSS content (16.03°Brix) was recorded in treatment control which was statistically at par with treatment Marigold flower extract (15.30°Brix) whereas lowest TSS was recorded in perforated plastic (13.43°Brix) which was statistically at par with treatments Newspaper wrapping (14.18°Brix), Neem leaf extract (14.53°Brix), Asuro leaf extract (14.33°Brix) and Titepati leaf extract treated (14.53°Brix). The pH was found highest in treatment control than that of other treatment throughout the storage period whereas low marketability rating (2.25), low pathological disorder rating (2.75) and longest postharvest life (62 days) was found in treatment perforated plastic.*

Keywords*— *Mandarin, Post-harvest, Plant extracts, Perforated Plastic.

I. INTRODUCTION

Nepal is developing country which mainly depends upon agriculture-based economy. Agriculture is the backbone of Nepalese economy contributing 31.7% to the national economy (AICC, 2017). Agriculture alone contributes 26.24 % of the Gross Domestic Product (GDP) and more than 50% of the population is engaged in this sector. Among the agricultural crops, fruit contributes about 7% of total Agriculture Gross Domestic Product (MoAD, Statistical Information and Nepalese Agriculture, 2016). Citrus fruit which includes oranges, mandarins, grapefruits, limes, and lemons is the major fruit for human diets. Among this Mandarin is the second leading citrus crop after sweet orange. In Nepal, about 22.44% of total fruit production is contributed by citrus and out of which mandarin contributes about 66.97% of total citrus production. In Nepal citrus is grown successfully in more than 55 districts and occupies 20th position in world's mandarin production (Rokaya, 2017). The mid hill region has a comparative advantage in the cultivation of citrus fruits, especially mandarin and sweet orange and are produced in large quantity in mid hills of Nepal stretching from east to west. The north facing mid hills are the main area of citrus cultivation because of cold wind, wet and highly water retentive soil, less light intensity (Shrestha, 2001).

The major causes of postharvest losses in Nepal are harvesting at an improper stage of maturity, improper method of harvesting, insufficient grading, and sorting, improper methods and materials of packing, poor transportation handling, and storage (Adhikari, 2006). Mandarin orange is harvested during November and December (Mangsir to Magh) and at this time there is the high availability of mandarin in the market (Kalimati Fruits And Vegetable Market Development Board, 2069). But the attack of the blue (*Penicillium italicum*) and green (*P. digitatum*) molds causes post–harvest decays of citrus fruits in cold storage. By proper storage undesirable process like rooting, sprouting, toughening, ripening and greening process are minimized. According to (Shrestha, Shakya, Baral, & Gautam, 1993), most important factors for storage are commodity itself, physiochemical environment and microbial environment. The commodity should be properly matured healthy and should be able to tolerate adverse environmental condition.

Nearly 20-25 percent of mandarin fruits are wasted due to faulty postharvest management i.e.7% during harvesting, 25% during transportation, 3% while grading, 10% in packaging, 5% during marketing (Bhattarai, Rijal, & Mishra, 2013). Temperature, relative humidity, air velocity, and atmospheric composition (concentrations of oxygen, carbon dioxide, and ethylene) and sanitation procedures are the different factors on which rate of biological deterioration of commodity depends. Minimizing postharvest losses of horticultural perishable is a very effective way of reducing the area needed for production and /or increasing food availability.

A possible alternative to solve post-harvest losses is the use of plant based products having antifungal properties. Plants generally produce many secondary metabolites which constitute an important source of micro-biocides, pesticides and many pharmaceutical drugs. Extracts from plants such as *Azadirachta indica*, *Allium sativum, Lippea javanicum, Urtica massaica, Adhatoda spp* and *Zingiber officinale*are reported to possess antimicrobial activity against a wide range of phytopathogens (Makeredza, Sibiya, & Madakadze, 2005). Neem oil extract can be used to prolong post-harvest life of mandarin (Karki, 2003). Deshmukh, Chavan, & Renapurkar (1982) have reported the beneficial effect of *Tagetes erecta* (Marigold) flower on various horticultural and agricultural crops, which are attributed primarily to the presence of an organic compound ‘camacin’ exhibiting antifungal and insecticidal effect. *Artemisia absinthium* can be used against *Alternaria* rot, *Penicillium expansum, Penicillium digitatum*, Blue mold (Parveen, Wani, Bhat, Pala, & Ganie, 2014). They are also reported to act as anti-feeding and antirepellent agents against various storage pathogens. Gonzalez, Vasquez, Felix, & Baez reported that plastic covering plays an important role in preventing dehydration by creating a saturated micro-atmosphere around the fruit. Reduction in PLW of polythene packed fruits could be attributed to retention of fruits in green fresh and firm form. Moreover, the polyethylene films have the characteristic feature of reducing the rate of transpiration by restricting the diffusion of gases and feedback mechanism.

In our country, there is limited research and study in this field. Along with this study, this research had objective to develop effective postharvest treatment for increasing shelf life and maintaining quality of mandarin under ambient condition.

II. MATERIALS AND METHODS

The laboratory experiment to assess the effect of different plant extracts and packaging materials on prolonging shelf-life and maintaining quality of Mandarin consists of following details:

2.1 Experimental location:

The experiment was carried out in Citrus zone office under supervision of Prime Minister Agricultural Modernization Project (PMAMP) situated at Tamghas, Gulmi district of Nepal. Gulmi is the district located on the Mid-Hill ecological belt in the north east of Nepal. It extends from 28° 4' 0'' N latitude to 83° 15' 0'' E longitude. The experimental location was situated at the altitude of 1530m above sea level.

Experimental Design:

The experiment was carried out in Completely Randomized Design (CRD) with four replications and seven treatments. The seven treatments that were used during experiment are given below:

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Table 1: Treatments details

SN	Abbreviations	Treatments	Concentration	Time duration of dipping
1	T1	Control	distil water	-
2	T2	Titepati leaf extract	1:10(paste:water)	1 minutes 30 seconds
3	T3	Marigold flower extract	1:10(paste:water)	1 minutes 30 seconds
4	T4	Asuro leaf extract	1:10(paste:water)	1 minutes 30 seconds
5	T5	Neem leaf extract	1:10(paste:water)	1 minutes 30 seconds
6	T6	Newspaper wrapping	One fold and stitching the Newspaper	
7	T7	Perforated plastic	500 g fruits in each plastic with 5 holes	

2.2 Collection and Selection of Mandarin:

About 300, fully matured, ripened and medium uniform size mandarin fruits were collected directly from the orchard of farmers situated near to Citrus zone office, Tamghas, Gulmi district. The abnormal, pathological and physiologically disordered mandarins were rejected. For each treatment in each replication, 8 fruits were separated among which 3 fruits used as non-destructive sample and remaining 5 fruits used as destructive sample.

2.3 Preparation of different treatment solution:

For the preparation of different botanical extracts, fresh leaves of Neem, Asuro, Titepati and flower of marigold respectively were collected and their paste were made using mixture. About 1 part of freshly prepared paste was mixed in 10 parts of distilled water to make dilute solution of particular paste. These dilute pastes were allowed to remain for 24 hours and taken for filtration to get the proper liquid solution. Perforated plastic (5 holes) and Newspaper were brought from the market.

2.4 Treatment of mandarin with prepared solution:

The selected mandarin fruits were washed properly in running water and taken for shade drying. Fruits were dipped for 1 minute and 30 second.

2.5 Experimental Setup:

Experiment was carried out in the ambient room condition. Hygrometer was kept inside the experimental room in order to record daily maximum-minimum temperature and relative humidity. Four replications were made and within each replication seven treatments were placed.

In each treatment, five destructive and three non-destructive samples of treated fruits were placed separately in tray.

2.6 Data collection and analysis:

The different parameters that were taken during experiment as given below:

2.6.1 Weight loss percentage:

The weight was taken from non-destructive sample of each treatment of each replication by using digital weighing machine. The initial weight of each treatment from each replication was taken during the experimental setup time and successive weight was taken at every 4 days interval. The weight loss percentage was calculated by using formula:

$$\text{Weight loss percentage} = \frac{\text{Initial fresh weight} - \text{successive weight}}{\text{Initial fresh weight}} * 100\%$$

2.6.2 Pathological disorder rating:

The pathological disorder rating was analyzed from non-destructive sample of each treatment of each replicationat every 4 days interval of experimental setup.An arbitrary numbers was set and numbers was given through visual inspection as:

“1” - No disorder

“2” - Slightly disorder

“3” - Moderately disorder

“4” - Highly disorder.

2.6.3 Marketability rating:

The marketability condition was analyzed from non-destructive sample of each treatment of each replicationat every 4 days interval of experimental setup.An arbitrary number was set and number was given through visual inspection as:

"1" - Highly marketable

"2" - Moderately marketable

"3" - Slightly marketable

"4" - No marketable

2.6.4 Juice Content Percentage**:**

The juice content was taken from one destructive sample of each treatment of each replication by squeezing through manual methodat every 7 days interval of experimental setup successively for 5 times. The sample was taken; its initial weight was measured using weighing machine before squeezing. After that cut sample was cut, squeezed and squeezed juice was placed in the small measuring beaker and finally volume (ml) of juice was recorded for each sample from each treatment separately. The juice content percentage in individual sample was calculated as:

$$\text{Juice content percentage} = \frac{\text{Total juice content}}{\text{Total Initial Weight}} * 100\%$$

2.6.5 Total Soluble Sugar (TSS):

The total soluble sugar present in juice was determined using hand held refractometer. One destructive sample from each treatment of each replication was taken, volume of juice was measured after squeezing and finally TSS was measured in brix using refractometer at every 5 days interval of experimental setup successively for 5 times.

2.6.6 pH:

pH of the juice was measured with the help of digital pH meter.

2.6.7 Temperature and Relative humidity (RH):

Temperature and RH were recorded each day during the experimental period using thermo-hygrometer.

2.6.8 Statistical method:

The data pertaining to various parameters were collected at different stages and intervals and tabulated in an Excel sheet for analysis as mentioned by Gomez and Gomez (1984). All routine statistical analysis was carried out using R-studio software version 3.4.5. This software was used to generate Analysis of Variance (ANOVA) and LSD test at 0.05 ($p<=0.05$) to determine the significant difference among the treatment means.

III. RESULT AND DISCUSSION

3.1 Physiological loss in weight (PLW)

The physiological loss in weight (PLW) was increased in all the treatments with the advancement of the storage period. No significant result was recorded among different treatment till 7th days of storage but it was found statistically different from 11th to 51th days of experiment. The highest percentage of PLW was observed in control (35.47) which was at par with Newspaper wrapping (33.28). The lowest percentage of physiological loss in weight was observed in Perforated plastic (16.32) followed by Neem extract treated fruits (31.70) which was at par with Marigold extract treated fruits (31.73), Asuro extract treated fruits (31.76) and Titepati extract treated fruits (32.19) (Table 2). The similar results were obtained by Bhattarai et al., (2017) in which minimum physiological loss in weight was observed in perforated plastic and maximum in control. Fruits in newspaper produced higher rates of transpiration which resulted in decreased weight due to loss of moisture (Bhattarai & Shah, 2017). Low weight loss was noted in fruits packed in plastic wrapping because of modified atmosphere created that reduced levels of transpiration and evaporation within the package. Gonzalez et al., (1997) also reported that plastic covering plays an important role in preventing dehydration by creating a saturated micro-atmosphere around the fruit resulting in low weight loss. The finding of Farooqi et al., (1975) also supports my findings. The polyethylene films have the characteristic feature of reducing the rate of transpiration by restricting the diffusion of gases and feedback mechanism. Neem extract treated fruits also showed low (31.70) physiological loss in weight. It might be because of the ability of Neem leaf extract to retard the moisture loss and to delay the senescence process (Gakhukar, Commercial and industrial aspects of neem based pesticide., 1996). Other probable reason for this might be the ability of Neem leaves to restrict the growth of micro-organisms responsible for rotting (Singh & Acharya, 2000). The reduced weight loss might also be due to the formation of thin layer of oil on surface of fruits that reduced the evapotranspiration and respiration rate in the treated fruits (Singh & Acharya, 2000). Samanta & Prasad (1996) had also reported the positive effects of botanical leaf extracts on minimizing the water vapor losses. Silva (2004) states the essential oils present in Titepati (Artemisia vulgaris) acts as antiseptic, antioxidant, antifungal, antibacterial and antiviral agent that prevent fruits from harmful microbial activity which might be a factor resulting in lower weight loss. Deshmukh, Chavan, & Renapurkar (1982) have reported the beneficial effect of Tagetes erecta (Marigold) flower on various horticultural and agricultural crops, which are attributed primarily to the presence of an organic compound ‘camacin’ exhibiting antifungal and insecticidal effect which might be a factor for low weight loss. Ethyl acetate extracts of Asuro (Adhatoda vasica) acts as antifungal agent storage pathogens which might be the reason for low weight loss (Ishnava et al., 2011).

Table 2: Effect of postharvest treatments on physiological weight loss (%) of mandarin fruit during storage at ambient condition (14.42±1.28°c, 58.46±3.46% RH), Gulmi, Nepal, (2019)

	The physiological loss in weight (%) on days indicated									
Treatments	**Day3**	**Day7**	**Day11**	**Day15**	**Day19**	**Day23**	**Day27**	**Day31**	**Day47**	**Day51**
Control	1.54	3.26	5.79^{a}	10.12^{a}	14.03^{a}	14.83^{a}	17.44^{a}	20.73^{a}	34.34^{a}	35.47^{a}
Titepati	1.59	3.53	5.57^{ab}	7.58^{c}	8.84^{a}	11.38^{b}	13.66^{bc}	16.76^{bc}	30.15^{b}	32.19^{b}
Marigold	1.55	3.60	4.78^{b}	8.96^{b}	7.75^{b}	12.62^{b}	14.11^{bc}	13.81^{d}	26.31^{c}	31.73^{b}
Asuro	1.20	3.27	5.00^{ab}	7.09^{c}	8.15^{b}	10.91^{b}	12.90^{c}	15.41^{cd}	28.56^{bc}	31.76^{b}
Neem	1.13	2.97	5.24^{ab}	6.98^{c}	8.85^{b}	11.50^{b}	13.77^{bc}	16.96^{bc}	28.88^{bc}	31.70^{b}
Newspaper	1.57	2.84	4.60^{b}	6.53^{c}	7.98^{b}	11.61^{b}	15.14^{b}	17.84^{b}	29.09^{bc}	33.28^{ab}
Perforated Plastic	1.54	2.23	3.09^{c}	3.95^{d}	4.38^{c}	5.32^{c}	6.01^{d}	7.30^{e}	13.48^{d}	16.32^{c}
F-test	NS	NS	***	***	***	***	***	***	***	***
CV, %	14.2	11.5	12.2	10.1	10.4	12.7	11.2	8.09	6.87	5.97
SEm(±)	.067	.131	.186	.569	.347	.566	.676	.779	1.207	1.168
LSD	.512	.886	.875	1.17	1.22	2.09	2.19	1.85	2.75	2.67
GM	1.45	3.1	4.87	7.88	8.01	11.2	13.3	15.6	27.3	30.4

(Note:- Means with the same letter do not differ significantly at p=.05 by DMRT, CV= Coefficient of variance, LSD= Least significant difference, SEM= Standard error of mean and GM= Grand mean.)

3.2 Juice recovery percentage

The juice recovery percentage was decreased with time during the storage in all the treatments. No significant result was recorded among different treatment till 9th days of storage but it was found statistically different from 14th to 24th days of experiment. At the end of experiment, the maximum juice recovery percentage was observed in treatment perforated plastic (36.12). Similarly, the minimum juice recovery percentage was observed in control (26.70) which was at par with Newspaper-wrapping (27.24) followed by Titepati treated mandarin (30.34) which was at par with Neem treated mandarin (30.73), Asuro treated mandarin (31.63) and Marigold treated mandarin (32.15) (Table 3). The trend of decrease in juice percentage during the storage was might be due to loss of moisture from the surface of the fruits. The perforated plastic created the modified atmospheric environment which reduced the moisture loss from the fruit attributed by low respiration rate resulting in the higher juice recovery percentage Similarly botanical extract treatment also exhibited higher juice recovery percentage as compared to control due to their anti-bacterial and fungicidal properties. Formation of thin layer of oil on surface of fruits treated with botanical extract that reduced the evapotranspiration and respiration rate in the treated fruits (Singh & Acharya, 2000) that reduced the moisture loss and ultimately higher juice recovery percentage.

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Table 3: Effect of postharvest treatments on juice recovery (%) of mandarin fruit during storage at ambient condition (14.42±1.28°c, 58.46±3.46% RH), Gulmi, Nepal, (2019)

		Juice recovery % of fruit on days indicated				
S.N.	**Treatments**	**Day4**	**Day9**	**Day14**	**Day19**	**Day24**
1	Control	43.43	35.61	32.62^{e}	30.61^{d}	26.70^{c}
2	Titepati	44.29	38.71	35.80^{d}	33.07^{bcd}	30.34^{b}
3	Marigold	41.33	37.67	33.32^{de}	35.62^{b}	32.15^{b}
4	Asuro	47.56	41.33	38.95^{bc}	35.40^{b}	31.63^{b}
5	Neem	44.69	40.97	36.56^{cd}	33.92^{bc}	30.73^{b}
6	Newspaper	47.17	42.43	40.41^{ab}	31.82^{cd}	27.24^{c}
7	Plastic	48.28	41.47	40.42^{a}	39.98^{a}	36.12^{a}
	F-Test	NS	NS	***	***	***
	CV	11.2	9.14	4.88	5.23	6.85
	SEm(±)	.959	.749	.621	.624	.665
	LSD	7.48	5.34	2.64	2.64	3.09
	GM	45.3	39.7	36.70	34..3	30.7

(Note: -Means with the same letter do not differ significantly at p=.05 by DMRT, CV= Coefficient of variance, LSD= Least significant difference, SEM= Standard error of mean and GM= Grand mean)

3.3 Total soluble solutes (TSS)

The TSS of the fruit increased with increasing in the storage period. No significant result was recorded among different treatment till 14th days of storage but it was found statistically different at 19th and 24th days of experiment. At the end of experiment, the highest TSS was found in control (16.03) which was at par with Marigold (15.30) treated mandarin (15.30). The lowest TSS was found in perforated plastic storage (13.43) which was at par with Titepati treated (14.33), Asuro (14.33) treated mandarin, Neem treated mandarin and Newspaper storage (14.18). From the very beginning of the observation, TSS was increased in every destructive test but it was maximum in control and lower in Perforated Plastic storage (Table 4). The increase in TSS content during storage might be due to the moisture loss, hydrolysis of polysaccharides and concentration of juice as a result of degradation. Lower sugar content in fruits from plastic packaging was due to lower rate of metabolic processes. Polythene provides a protective covering which slowed down the rate of respiration and delayed ripening as stated by (Khumlert, 1992). This fact is also supported (Hoque, Chowhan, & Kamruzzaman, 2017) in which TSS was minimal in fruits kept in thin plastic film. Neem also exhibited lower TSS which might be due to the action of Neem ingredients (*Azadirachtin*) that have antifungal properties and also the thin film of Neem oil on surface of fruits reduced the evapotranspiration and respiration rate and showed minimum decay thus preventing the rapid rise of TSS (Singh & Acharya, 2000). Chauhan & Joshi (1990) also reported that botanical extracts performed better in retaining the total soluble solids in Ratna cv. of mango.

Table 4 Effect of postharvest treatments on TSS of mandarin fruit during storage at ambient condition (14.42±1.28°c, 58.46±3.46% RH), Gulmi, Nepal, (2019)

		Total Soluble Sugar (TSS) (Brix) of fruits on days indicated				
S.N.	**Treatments**	**Day4**	**Day9**	**Day14**	**Day19**	**Day24**
1	Control	12.37	13.50	13.85	14.55^{ab}	16.03^{a}
2	Titepati	12.18	12.15	13.28	13.58^{abc}	14.53^{bc}
3	Marigold	11.20	12.80	13.25	14.75^{a}	15.30^{ab}
4	Asuro	11.83	12.63	13.20	13.53^{bc}	14.33^{bc}
5	Neem	12.05	12.18	13.13	13.78^{abc}	14.53^{bc}
6	Newspaper	11.63	12.95	13.05	13.50^{bc}	14.18^{bc}
7	Perforated Plastic	11.20	11.70	11.98	12.68^{c}	13.43^{c}
	F-test	NS	NS	NS	*	**
	CV	8.14	6.22	5.59	5.38	4.89
	SEm(±)	.180	.168	.158	.175	.190
	LSD	1.41	1.15	1.08	1.09	1.05
	GM	11.8	12.6	13.1	13.8	14.6

(Note: - Means with the same letter do not differ significantly at p=.05 by DMRT, CV= Coefficient of variance, LSD= Least significant difference, SEM= Standard error of mean and GM= Grand mean)

3.4 pH of the fruit

The ph. value of juice was found increasing as the storage time period increased. At 24 days, the highest ph. value was observed in control (4.63) followed by perforated plastic (4.50), Titepati (4.49), Newspaper (4.47), Asuro (4.43), Marigold (4.36) respectively and lowest pH was observed in treatment Neem (4.30) (Table 5). In comparison, the pH of the treated fruits was found to be lower than pH of the fruits of control set, which might be due to the differences in the modified atmosphere created by different types of treatments. This phenomenon of increasing trend of pH during storage might be possible due to the oxidation of acids resulting in higher pH (Islam, Khan, Sarkar, Absar, & Sarkar, 2013). The fluctuations of pH might be due to the variations in temperature of storage and the decline of acidity which is attributed due to increased activities of citric acid glyoxylase during ripening. Reduction in acid content may be due to their conversion into sugars in metabolic process during storage (Rathore, Masud, Sammi, & Soomro, 2007).

Table 5: Effect of postharvest treatments on pH of mandarin fruit during storage at ambient condition (14.42±1.28°c, 58.46±3.46% RH), Gulmi, Nepal, (2019)

		pH of the fruit juice			
S.N	Treatments	Days 4	Days 9	Days19	Days 24
1	Control	3.895	3.990	4.220	4.625
2	Titepati	3.700	4.075	4.187	4.495
3	Marigold	3.620	3.927	4.015	4.362
4	Asuro	3.740	3.902	3.890	4.427
5	Neem	3.737	3.790	3.890	4.300
6	Newspaper	3.657	3.927	4.065	4.472
7	Perforated Plastic	3.982	4.025	4.240	4.500
	Grand Mean	3.760	3.950	4.100	4.450

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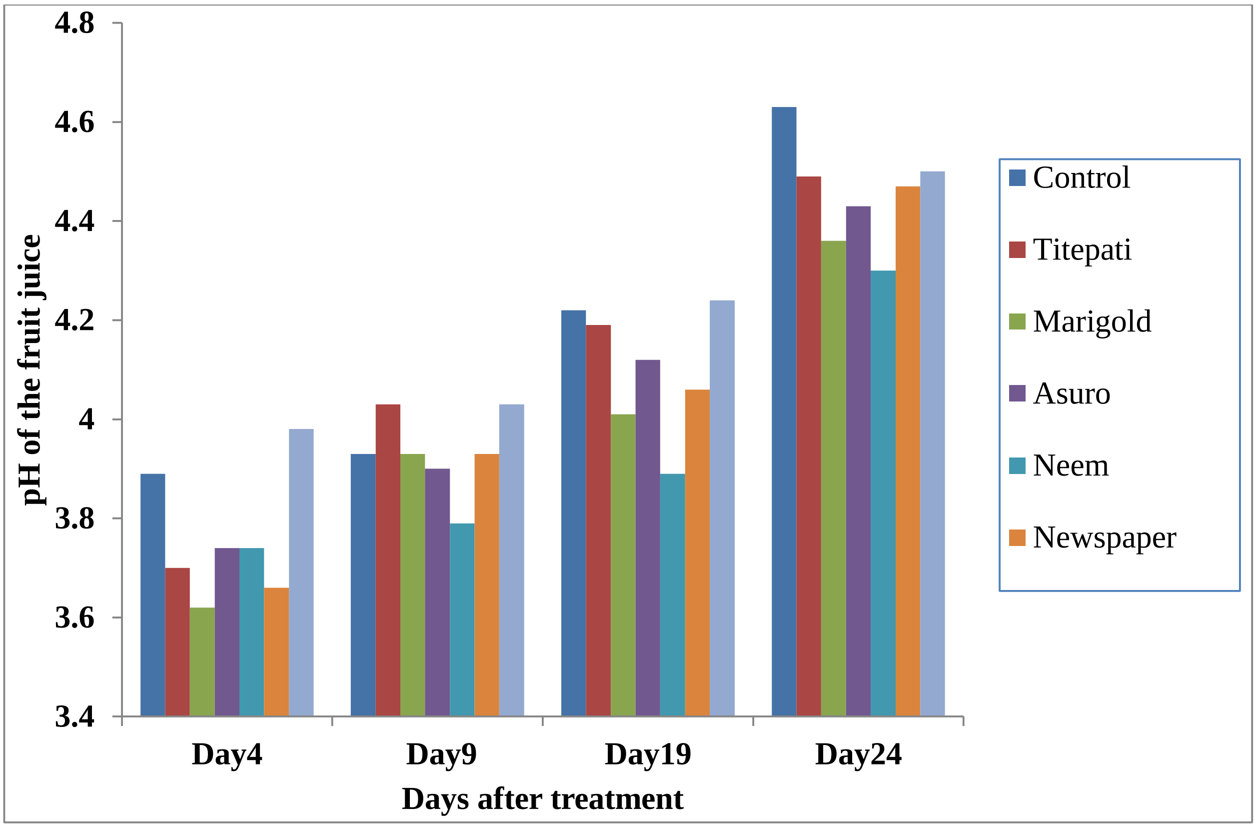

Fig.1: Effect of treatments on pH of the fruit juice at different days

3.5 Pathological disorder rating

Significant rating was observed from 16th days of storage. The pathological disorder was observed first in control, Asuro treated fruits and Newspaper wrapping at 16th days of storage followed by Marigold treated fruits (20 days), Titepati treated fruits (24 days), Neem treated fruits (32 days) and Perforated plastic (36 days). The rating was increased as time of storage increased. At 52 days of storage, the significantly highest rating was observed in treatment control (3.75) which was at par with Newspaper wrapping (3.75), Marigold treated fruits (3.25) and Asuro treated fruits (3.50). Similarly, lowest rating was observed in perforated plastic (2.75) which was at par with Neem treated fruits (3.0) and Titepati treated fruits (3.00) (Table 6). The lowest rating for perforated plastic might be due to inhibition of pathogenic spores due to modified environment created. The Neem, Titepati, Asuro and Marigold treated fruit also exhibit low pathological disorder which might be due to their essentials oils that created thin film of covering in fruits that inhibit the growth of fungal spores as described in 4.1.

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Table 6: Effect of postharvest treatments on Pathological disorder rating of mandarin fruit during storage at ambient condition (14.42±1.28°c mean temperature, 58.46±3.46% RH), Gulmi, Nepal, (2019)

		Pathological Disorder Rating(1-4)											
SN	**Treatments**	**4days**	**12days**	**16days**	**20days**	**24days**	**28days**	**32days**	**36days**	**40days**	**44days**	**48days**	**52days**
1	Control	1.00	1.00	1.50^{ab}	2.00^{a}	2.00^{a}	2.00^{a}	2.50^{a}	2.75^{a}	3.00^{a}	-	-	-
2	Titepati	1.00	1.00	1.00^{b}	1.00^{b}	1.50^{b}	1.75^{a}	2.00^{ab}	2.00^{bc}	2.50^{b}	3.00	3.00	3.00
3	Marigold	1.00	1.00	1.00^{b}	1.50^{ab}	2.00^{a}	2.00^{a}	2.50^{a}	2.75^{a}	3.00^{a}	3.00	3.00	-
4	Asuro	1.00	1.00	1.75^{a}	1.75^{a}	2.00^{a}	2.00^{a}	2.00^{ab}	3.00^{a}	3.00^{a}	3.00	-	-
5	Neem	1.00	1.00	1.00^{b}	1.00^{b}	1.00^{c}	1.00^{b}	1.75^{b}	2.00^{bc}	2.00^{c}	2.25	2.75	3.00
6	Newspaper	1.00	1.00	1.25^{ab}	1.75^{a}	1.75^{ab}	1.75^{a}	2.25^{ab}	2.50^{ab}	2.75^{ab}	3.00	3.00	-
7	Plastic	1.00	1.00	1.00^{b}	1.00^{b}	1.00^{c}	1.00^{b}	1.00^{c}	1.75^{c}	2.00^{c}	2.00	2.00	2.75
	F-test	NS	NS	*	***	***	***	***	**	***	NS	NS	NS
	LSD	-	-	.507	.507	.424	.393	.600	.578	.424	-	-	-
	CV	-	-	28.4	24.2	18	16.3	20.4	16.4	11.1	-	-	-
	SEm(±)	-	-	.079	.095	.094	.092	.115	.107	0.094	-	-	-
	GM	-	-	1.21	1.43	1.61	1.64	2.0	2.39	2.61	-	-	-

(Note: - Means with the same letter do not differ significantly at p=.05 by DMRT, CV= Coefficient of variance, LSD= Least significant difference, SEM= Standard error of mean and GM= Grand mean)

3.6 Marketability Rating

The marketability rating was observed increasing as the storage time increased. At 20th days of storage, significant highest rating was observed in Control (2.00) and lowest rating in perforated plastic followed by Neem treated mandarin (1.00). At 32th days significantly highest rating was observed in control (2.50) which was at par with Newspaper wrapping (2.00) and Asuro treated fruits (2.25). Similarly, lowest rating was observed in Perforated plastic (1.00) followed by Neem treated fruits (1.75). At 52th days of storage, significantly highest rating was observed in Asuro treated fruits (4.00) which was statistically at par with Control (4.00), Marigold treated mandarin (3.5) and Newspaper wrapping (3.25). Similarly, lowest rating was observed in perforated plastic (2.25) followed by Neem (3.00) and Titepati treated fruits (3.00) (Table 7).

Table 7: Effect of postharvest treatments on Marketability rating of mandarin fruit during storage at ambient condition (14.42±1.28°c mean temperature, 58.46±3.46% RH), Gulmi, Nepal, (2019)

		Marketability Rating (1 to 4)										
S.N	**Treatments**	**4days**	**12days**	**16days**	**20days**	**28days**	**32days**	**36days**	**40days**	**44days**	**48days**	**52days**
1	Control	1.00	1.00	1.75	2.00^{a}	2.00^{a}	2.50^{a}	2.25^{a}	2.75^{a}	-	-	-
2	Titepati	1.00	1.00	1.25	1.25^{bc}	2.00^{a}	2.00^{b}	2.00^{a}	2.00^{b}	2.75	2.75	3.00
3	Marigold	1.00	1.00	1.25	1.75^{ab}	1.75^{a}	2.00^{b}	2.00^{a}	2.00^{b}	3.00	3.00	-
4	Asuro	1.00	1.00	1.50	1.75^{ab}	1.75^{a}	2.00^{ab}	2.25^{a}	2.75^{a}	3.00	-	-
5	Neem	1.00	1.00	1.00	1.00^{c}	1.00^{b}	1.75^{b}	1.75^{ab}	2.00^{b}	2.25	2.50	3.00
6	Newspaper	1.00	1.00	1.75	1.75^{ab}	1.75^{a}	2.00^{ab}	2.00^{a}	2.25^{ab}	3.00	-	-
7	Plastic	1.00	1.00	1.00	1.00^{c}	1.00^{b}	1.00^{c}	1.25^{b}	1.75^{b}	2.25	2.25	2.25
	F-test	NS	NS	NS	***	***	***	*	***	NS	NS	NS

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CV	-	-	25.8	25.2	20.4	15.3	19.6	16.9	-	-	-
SEm(±)	-	-	.092	.096	0.094	.094	.094	.089	-	-	-
LSD	-	-	.642	.556	.481	.424	.556	.578	-	-	-
GM	-	-	1.36	1.5	1.61	1.89	1.93	2.32	-	-	-

(Note: - Means with the same letter do not differ significantly at p=.05 by DMRT, CV= Coefficient of variance, LSD= Least significant difference, SEM= Standard error of mean and GM= Grand mean)

3.7 Postharvest Life

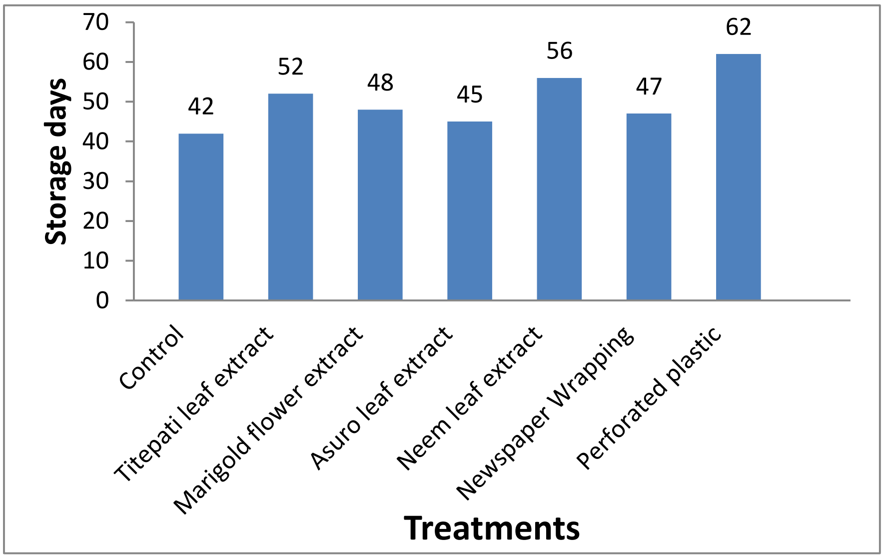

*Fig.2**:** Postharvest life of fruit at different treatments under ambient room condition.*

IV. CONCLUSION

Post-harvest loss in developing country like Nepal is quite high so, efficient post-harvest storage techniques with low cost must be invented. Prolongation of shelf life, as well as the quality of mandarin fruit, could be retained with the use of perforated plastic, Neem leaf extract and Titepati leaf extract. Prolonged shelf-life of mandarin fruits increased availability of mandarin for longer duration and increased export potential which fetches higher prices. Perforated plastic should be used to enhance the storage quality, shelf life and other physiochemical parameters of mandarin fruits and botanical extracts Titepati and Neem are also beneficial to enhance the shelf life with zero effect to the consumer health as compared to harmful chemicals.

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